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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: **Kenji FUJIWARA et al.**

Serial No.: **Not Yet Assigned**
(§ of international application No. PCT/JP01/04606)

Filed: **January 31, 2002**

For: **BRUSHLESS MOTOR**

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

January 31, 2002

Sir:

Prior to the calculation of the filing fees of the above application, please amend the application as follows:

IN THE SPECIFICATION:

Please replace the paragraph beginning at page 9, line 21, with the following rewritten paragraph:

Fig. 8A is a view explaining an effective magnet area rate Mgc;

Please replace the paragraph beginning at page 9, line 23, with the following rewritten paragraph:

Fig. 8B is a view explaining an effective magnet area rate Mgc;

Please replace the paragraph beginning at page 15, line 9, with the following rewritten paragraph:

The 14 permanent magnets 2_1 - 2_{14} are embedded in the rotor 1 and thus the density of magnetic force lines closed by a magnetic route in the rotor 1 is higher than that of the known motor

in Fig. 1. Such difference causes the values of L_q and L_d to be more asymmetrical, which results in the positive establishment of the following equation:

$$L_q > L_d, \qquad (4)$$

Please replace the paragraph beginning at page 19, line 13 and ending at page 20, line 1, with the following rewritten paragraph:

The North poles of the permanent magnets 34_1, 34_3, 34_5, 34_7, 34_9, 34_{11}, and 34_{13} among the permanent magnets 34 are located on the outer side of the rotor 31 in the radius direction, and their South poles are located on the inner side of the rotor 31. On the other hand, the South poles of the permanent magnets 34_2, 34_4, 34_6, 34_8, 34_{10}, 34_{12}, and 34_{13} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their North poles are located on the inner side in the radius direction of the rotor 31. That is, the two permanent magnets adjacent to each other among the permanent magnets 34 generate the magnetic force lines in the directions opposite to each other.

Please replace the paragraph beginning at page 36, line 12 and ending at page 37, line 1, with the following rewritten paragraph:

The North poles of the permanent magnets 34_1, 34_3, 34_5, 34_7, 34_9, 34_{11}, and 34_{13} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their South poles are located on the inner side of the rotor 31. On the other hand, the South poles of the

permanent magnets 34_2, 34_4, 34_6, 34_8, 34_{10}, 34_{12}, and 34_{14} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their North poles are located on the inner side in the radius direction of the rotor 31. That is, the two permanent magnets adjacent to each other among the permanent magnets 34 generate the magnetic force lines in the directions opposite to each other.

IN THE CLAIMS:

Please amend the following claims as follows:

2. (Amended) A brushless motor according to claim 1, wherein an output torque T of said brushless motor is given by a following equation:

$$T = p \{ \varphi \cdot I_a \cdot \cos(\beta) + (L_q - L_d) I_a^2 \sin(2\beta)/2 \},$$

p being a half of a number of said plurality of permanent magnets, φ being a maximum armature flux linkage generated by said plurality of permanent magnets, I_a being an armature current, β being a phase of said armature current, L_d being a direct-axis inductance of said rotor, and L_q being a quadrature-axis inductance of said rotor, while the following equation:

$$L_q \fallingdotseq L_d,$$

3. (Amended) A brushless motor according to claim 1, wherein the rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

10. (Amended) A brushless motor according to claim 7, said P satisfies the following equation:

$$12 \leq P \leq 30.$$

13. (Amended) A brushless motor according to claim 1, wherein said permanent magnet has a shape of a substantially rectangular parallelepiped, and

a distance d between a center of said rotor and magnetic pole surfaces opposed to said lateral surface among surfaces of said plurality of permanent magnets satisfies a following equation:

$d \leq r - D/10$,

where

$D = \pi r / P$, r being a radius of said rotor, and P is a number of said permanent magnets.

14. (Amended) A brushless motor according to claim 1, wherein a following equation:

$0 \leq (L_q\ L_d) / L_d \leq 0.3$,

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

15. (Amended) A brushless motor according to claim 1, wherein said magnetic force line inducing bodies include a direct axis magnetic force line inducing body for inducing magnetic fluxes in a direct axis direction of said rotor, and

wherein a gap extending in a quadrature axis direction of said rotor is formed in said rotor.

17. (Amended) A motor-driven vehicle comprising:

a plurality of drive wheels;

a power supply voltage supplier for supplying a power supply voltage; and

a brushless motor provided with said power supply voltage to drive said plurality of drive wheels, wherein said brushless motor includes:

a stator; and

a rotor having a lateral surface opposed to said stator, and said stator comprises:

a plurality of radially extending iron cores, and

a plurality of windings for respectively generating magnetic fields in said iron cores, and said rotor comprises:

a plurality of permanent magnets, and

magnetic force line induction bodies located between said permanent magnets and said lateral surface.

18. (Amended) A motor-driven vehicle according to claim 17, wherein an output torque T of said brushless motor is given by a following equation:

$$T = p\{\phi\ I_a\ \cos\ (\beta) + (L_q - L_d)I_a^2 \sin(2\beta)/2\},$$

p being a half of a number of said plurality of permanent magnets, ϕ being a maximum armature flux linkage generated by said plurality of permanent magnets, I_a being an armature current, β being a phase of said armature current, L_d being a direct-axis inductance of said rotor, and L_q being a quadrature-axis inductance of said rotor, while the following equation:

$$L_q \fallingdotseq L_d,$$

does not hold.

19. (Amended) A motor-driven vehicle according to claim 17, wherein said rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

Please add the following new claims:

20. A motor-driven vehicle according to claim 17, wherein three-phase direct currents are provided for said plurality of windings.

21. A motor-driven vehicle according to claim 20, wherein said plurality of windings include:

a first set of windings, and

a second set of windings, and

wherein said first set of three-phase windings and said second set of three-phase windings are arranged to be symmetrical with respect to a line.

22. A motor-driven vehicle according to claim 20, wherein said plurality of windings include:

a first group of three-phase windings, and

a second group of three-phase windings, and

wherein phase synchronous windings having said same phase of said first and second groups of three-phase windings are adjacent to each other in the same rotation direction, and

wherein said first group of three-phase windings comprise:

a first set of three-phase windings, and

a second set of three-phase windings, and said first set of three-phase windings and said second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line, and

wherein said second group of three-phase windings comprise:

another first set of three-phase windings and

another second set three-phase windings, and said other first set three-phase windings and said other second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line.

23. A motor-driven vehicle according to claim 17, wherein a number of said windings is N, and a number of said permanent magnets is P, and said P is greater than said N.

24. A motor-driven vehicle according to claim 23, wherein one of prime factors of said P is greater than any of prime factors of said N.

25. A motor-driven vehicle according to claim 24, wherein said prime factors of said N includes 2 and 3, and

said prime factor of said P includes 2 and 7.

26. A motor-driven vehicle according to claim 23, said P satisfies the following equation:

$12 \leq P \leq 30.$

27. A motor-driven vehicle according to claim 23, wherein said N is 12 and said P is 14.

28. A motor-driven vehicle according to claim 23, wherein a section of said permanent magnets on a flat plane vertical to a central axis of said rotor is rectangular,

said rectangle has short sides and long sides longer than said short sides, and

said long sides are opposed to said lateral surface.

29. A motor-driven vehicle according to claim 17, wherein said permanent magnet has a shape of a substantially rectangular parallelepiped, and

a distance d between a center of said rotor and magnetic pole surfaces opposed to said lateral surface among surfaces of said plurality of permanent magnets satisfies a following equation:

$d \leq r - D/10,$

where

$D = 2\pi r / P,$

r being a radius of said rotor, and P being a number of said permanent magnets.

30. A motor-driven vehicle according to claim 17, wherein a following equation:

$0 \leq (L_q L_d) / L_d \leq 0.3$,

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

31. A motor-driven vehicle according to claim 17, wherein said magnetic force line inducing bodies comprise a direct axis magnetic force line inducing body for inducing magnetic fluxes in a direct axis direction of said rotor, and

wherein a gap extending in a quadrature axis direction of said rotor is formed in said rotor.

32. A motor-driven vehicle according to claim 31, wherein a following equation:

$0 \leq (L_q L_d) / L_d \leq 0.3$,

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

33. An electric car comprising:

a plurality of drive wheels;

an accelerator pedal;

a power supply voltage supplier for supplying a power supply voltage based on a movement of said accelerator pedal; and

a brushless motor provided with said power supply voltage to drive said plurality of drive wheels, wherein said brushless motor includes:

a stator; and

a rotor having a lateral surface opposed to said stator, and said stator comprises:

a plurality of radially extending iron cores, and

a plurality of windings for respectively generating magnetic fields in said iron cores, and said rotor comprises:

a plurality of permanent magnets, and

magnetic force line induction bodies located between said permanent magnets and said lateral surface.

34. An electric car according to claim 33, wherein an output torque T of said brushless motor is given by a following equation:

$$T = p\{\phi\ I_a \cos(\beta) + (L_q - L_d) I_a^2 \sin(2\beta)/2\},$$

p being a half of a number of said plurality of permanent magnets, ϕ being a maximum armature flux linkage generated by said plurality of permanent magnets, I_a being an armature current, β being a phase of said armature current, L_d being a direct-axis inductance of said rotor, and L_q being a quadrature-axis inductance of said rotor, while the following equation:

$$L_q \fallingdotseq L_d,$$

does not hold.

[redacted]

35. An electric car according to claim 33, wherein said rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

36. An electric car according to claim 33, wherein three-phase direct currents are provided for said plurality of windings.

37. An electric car according to claim 36, wherein said plurality of windings include:

a first set of windings, and

a second set of windings, and

wherein said first set of three-phase windings and said second set of three-phase windings are arranged to be symmetrical with respect to a line.

38. An electric car according to claim 36, wherein said plurality of windings include:

a first group of three-phase windings, and

a second group of three-phase windings, and

wherein phase synchronous windings having said same phase of said first and second groups of three-phase windings are adjacent to each other in the same rotation direction, and

wherein said first group of three-phase windings comprise:

a first set of three-phase windings, and

a second set of three-phase windings, and said first set of three-phase windings and said second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line, and

wherein said second group of three-phase windings comprise:

another first set of three-phase windings and

another second set three-phase windings, and said other first set three-phase windings and said other second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line.

39. An electric car according to claim 33, wherein a number of said windings is N, and a number of said permanent magnets is P, and said P is greater than said N.

40. An electric car according to claim 39, wherein one of prime factors of said P is greater than any of prime factors of said N.

41. An electric car according to claim 40, wherein said prime factors of said N includes 2 and 3, and

said prime factor of said P includes 2 and 7.

42. An electric car according to claim 39, said P satisfies the following equation:

$12 \leq P \leq 30$.

43. An electric car according to claim 39, wherein said N is 12 and said P is 14.

44. An electric car according to claim 39, wherein a section of said permanent magnets on a flat plane vertical to a central axis of said rotor is rectangular,

said rectangle has short sides and long sides longer than said short sides, and

said long sides are opposed to said lateral surface.

45. An electric car according to claim 33, wherein said permanent magnet has a shape of a substantially rectangular parallelepiped, and

a distance d between a center of said rotor and magnetic pole surfaces opposed to said lateral surface among surfaces of said plurality of permanent magnets satisfies a following equation:

$$d \leq r - D/10,$$

where

$$D = 2\pi r / P,$$

r being a radius of said rotor, and P being a number of said permanent magnets.

46. An electric car according to claim 33, wherein a following equation:

$$0 \leq (L_q \ L_d) / L_d \leq 0.3,$$

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

47. An electric car according to claim 33, wherein said magnetic force line inducing bodies comprise a direct axis magnetic force line inducing body for inducing magnetic fluxes in a direct axis direction of said rotor, and

wherein a gap extending in a quadrature axis direction of said rotor is formed in said rotor.

48. An electric car according to claim 47, wherein a following equation:

$0 \leq (L_q\ L_d) / L_d$ £ 0.3,

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

49. An electric train comprising:

a plurality of drive wheels;

a throttle lever;

a power supply voltage supplier for supplying a power supply voltage based on a movement of said throttle lever;

a brushless motor provided with said power supply voltage to drive said plurality of drive wheels, wherein said brushless motor includes:

a stator; and

a rotor having a lateral surface opposed to said stator, and said stator comprises:

a plurality of radially extending iron cores, and

a plurality of windings for respectively generating magnetic fields in said iron cores, and said rotor comprises:

a plurality of permanent magnets, and

magnetic force line induction bodies located between said permanent magnets and said lateral surface.

50. An electric train according to claim 49, wherein an output torque T of said brushless motor is given by a following equation:

$$T = p\{\phi I_a \cos(\beta) + (L_q - L_d) I_a^2 \sin(2\beta)/2\},$$

p being a half of a number of said plurality of permanent magnets, ϕ being a maximum armature flux linkage generated by said plurality of permanent magnets, I_a being an armature current, β being a phase of said armature current, L_d being a direct-axis inductance of said rotor, and L_q being a quadrature-axis inductance of said rotor, while the following equation:

$$L_q \fallingdotseq L_d,$$

does not hold.

51. An electric train according to claim 49, wherein said rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

52. An electric train according to claim 49, wherein three-phase direct currents are provided for said plurality of windings.

53. An electric train according to claim 52, wherein said plurality of windings include:

a first set of windings, and

a second set of windings, and

wherein said first set of three-phase windings and said second set of three-phase windings are arranged to be symmetrical with respect to a line.

54. An electric train according to claim 52, wherein said plurality of windings include:

a first group of three-phase windings, and

a second group of three-phase windings, and

wherein phase synchronous windings having said same phase of said first and second groups of three-phase windings are adjacent to each other in the same rotation direction, and

wherein said first group of three-phase windings comprise:

a first set of three-phase windings, and

a second set of three-phase windings, and said first set of three-phase windings and said second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line, and

wherein said second group of three-phase windings comprise:

another first set of three-phase windings and

another second set three-phase windings, and said other first set three-phase windings and said other second set of three-phase windings are arranged to be approximately geometrically symmetrical with respect to a line.

55. An electric train according to claim 49, wherein a number of said windings is N, and a number of said permanent magnets is P, and said P is greater than said N.

56. An electric train according to claim 55, wherein one of prime factors of said P is greater than any of prime factors of said N.

57. An electric train according to claim 56, wherein said prime factors of said N includes 2 and 3, and said prime factor of said P includes 2 and 7.

58. An electric train according to claim 55, said P satisfies the following equation: $12 \leq P \leq 30$.

59. An electric train according to claim 55, wherein said N is 12 and said P is 14.

60. An electric train according to claim 49, wherein a section of said permanent magnets on a flat plane vertical to a central axis of said rotor is rectangular,

said rectangle has short sides and long sides longer than said short sides, and

said long sides are opposed to said lateral surface.

61. An electric train according to claim 49, wherein said permanent magnet has a shape of a substantially rectangular parallelepiped, and

a distance d between a center of said rotor and magnetic pole surfaces opposed to said lateral surface among surfaces of said plurality of permanent magnets satisfies a following equation:

$d \leq r - D/10,$

where

$D = 2\pi r / P,$

r being a radius of said rotor, and P being a number of said permanent magnets.

62. An electric train according to claim 49, wherein a following equation:

$0 \leq (L_q \; L_d) / L_d \leq 0.3,$

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

63. An electric train according to claim 49, wherein said magnetic force line inducing bodies comprise a direct axis magnetic force line inducing body for inducing magnetic fluxes in a direct axis direction of said rotor, and

wherein a gap extending in a quadrature axis direction of said rotor is formed in said rotor.

64. An electric train according to claim 49, wherein a following equation:

$0 \leq (L_q \; L_d) / L_d \leq 0.3,$

holds, where L_q is a quadrature-axis inductance of said rotor, and L_d is a direct-axis inductance of said rotor.

REMARKS

The above amendment is believed to correct typographical errors in the specification and place the claims in proper condition for examination. Early and favorable action is awaited.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with markings to show changes made."

In the event there are any additional fees required, please charge our Deposit Account No. 01-2340.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

The paragraph beginning at page 9, line 21, has been amended as follows:

~~Figs.~~ Fig. 8A is a view explaining an effective magnet area rate Mgc;

Please replace the paragraph beginning at page 9, line 23, with the following rewritten paragraph:

~~Figs.~~ Fig. 8B is a view explaining an effective magnet area rate Mgc;

The paragraph beginning at page 15, line 9, has been amended as follows:

The 14 permanent magnets 2_1 - 2_{14} are embedded in the rotor 1 and thus the density of magnetic force lines closed by a magnetic route in the rotor 1 is higher than that of the known motor in Fig. 1. Such difference causes the values of L_q and L_d to be ~~further targetless~~ more asymmetrical, which results in the positive establishment of the following equation:

$$L_q > L_d, \quad (4)$$

The paragraph beginning at page 19, line 13 and ending at page 20, line 1, has been amended as follows:

The North poles of the permanent magnets 34_1, 34_3, 34_5, 34_7, 34_9, 34_{11}, and 34_{13} among the permanent magnets 34 are located on the outer side of the rotor 31 in the radius direction, and their South poles are located on the inner side of the rotor 31. On the other hand, the ~~North~~ South

poles of the permanent magnets 34_2, 34_4, 34_6, 34_8, 34_{10}, 34_{12}, and 34_{13} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their ~~South~~ North poles are located on the inner side in the radius direction of the rotor 31. That is, the two permanent magnets adjacent to each other among the permanent magnets 34 generate the magnetic force lines in the directions opposite to each other.

The paragraph beginning at page 36, line 12 and ending at page 37, line 1, has been amended as follows:

The North poles of the permanent magnets 34_1, 34_3, 34_5, 34_7, 34_9, 34_{11}, and 34_{13} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their South poles are located on the inner side of the rotor 31. On the other hand, the ~~North~~ South poles of the permanent magnets 34_2, 34_4, 34_6, 34_8, 34_{10}, 34_{12}, and 34_{14} among the permanent magnets 34 are located on the outer side in the radius direction of the rotor 31, and their ~~South~~ North poles are located on the inner side in the radius direction of the rotor 31. That is, the two permanent magnets adjacent to each other among the permanent magnets 34 generate the magnetic force lines in the directions opposite to each other.

3. (Amended) A brushless motor according to claim 1, wherein ~~said~~ the rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

10. (Amended) A brushless motor according to claim 7, said P satisfies ~~an~~ the following equation:

$$12 \leq P \leq 30.$$

13. (Amended) A brushless motor according to claim 1, wherein said permanent magnet has a shape of a substantially rectangular parallelepiped, and

a distance d between a center of said rotor and magnetic pole surfaces opposed to said lateral surface among surfaces of said plurality of permanent magnets satisfies a following equation:

$$d \leq r - D/10,$$

where

$D = \pi r / P$, r~~:~~ being a radius of said rotor, and P~~:~~ is a number of said permanent magnets.

14. (Amended) A brushless motor according to claim 1, wherein a following equation:

$$0 \leq (L_q \ L_d) \ / \ L_d \leq 0.3,$$

holds, where L_q~~:~~ is a quadrature-axis inductance of said rotor, and L_d~~:~~ is a direct-axis inductance of said rotor.

15. (Amended) A brushless motor according to claim 1, wherein said magnetic force line inducing bodies include a direct axis magnetic force line inducing body for inducing magnetic fluxes in a direct axis direction of said rotor, and

wherein a gap extending in ~~the~~ a quadrature axis direction of said rotor is formed in said rotor.

17. (Amended) A motor-driven vehicle comprising:

a plurality of drive wheels;

~~said brushless motor according to any one of claims 1 to 16, wherein said rotor included in said brushless motor drives said drive wheels; and~~

a power supply voltage supplier for supplying a power supply voltage ~~to said brushless motor~~; and

a brushless motor provided with said power supply voltage to drive said plurality of drive wheels, wherein said brushless motor includes:

a stator; and

a rotor having a lateral surface opposed to said stator, and said stator comprises:

a plurality of radially extending iron cores, and

a plurality of windings for respectively generating magnetic fields in said iron cores, and said rotor comprises:

a plurality of permanent magnets, and

magnetic force line induction bodies located between said permanent magnets and said lateral surface.

18. (Amended) ~~An electric car comprising:~~

~~drive wheels;~~

~~said brushless motor according to any one of claims 1 to 16, wherein said rotor included in said brusless motor drives said drive wheels;~~

~~a power supply voltage supplier for supplying a power supply voltage to said brushless motor, on the basis of a movement of an accelerator pedal~~.

A motor-driven vehicle according to claim 17, wherein an output torque T of said brushless motor is given by a following equation:

$$T = p\{\phi \ I_a \ \cos(\beta) + (L_q - L_d) I_a^2 \sin(2\beta)/2\},$$

p being a half of a number of said plurality of permanent magnets, ϕ being a maximum armature flux linkage generated by said plurality of permanent magnets, I_a being an armature current, β being a phase of said armature current, L_d being a direct-axis inductance of said rotor, and L_q being a quadrature-axis inductance of said rotor, while the following equation:

$$L_q \fallingdotseq L_d,$$

does not hold.

19. (Amended) ~~An electric train comprising:~~

~~drive wheels;~~

~~said brushless motor according to any one of claims 1 to 16, wherein said rotor included in said brushless motor drives said drive wheels;~~

~~a power supply voltage supplier for supplying a power supply voltage to said brushless motor, on the basis of a movement of a throttle lever.~~

A motor-driven vehicle according to claim 17, wherein said rotor has a plurality of holes into each of which said plurality of permanent magnets are inserted in an axis direction of said rotor.

Fig. 8A

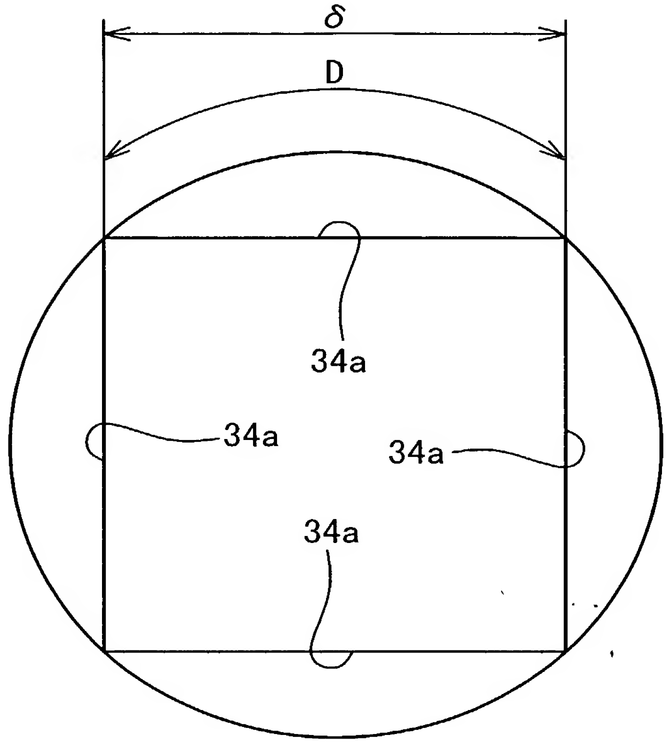

Fig. 8B